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THE INFLUENCE OF DROUGHT, AND  
OTHER ABIOTIC FACTORS ON TREE  
WATER USE IN A TEMPERATE REMNANT  
FOREST

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## Declaration

I certify that the work in this thesis has not previously been submitted for a degree nor has it been submitted as part of requirements for a degree except as fully acknowledged within the text.

I also certify that the thesis has been written by me. Any help that I have received in my research work and the preparation of the thesis itself has been acknowledged. In addition, I certify that all information sources and literature used are indicated in the thesis.

  
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Work from this thesis has directly contributed to the following papers:

Zeppel M.J.B., Yunusa I.A.M. and Eamus D., Daily, seasonal, and annual patterns of transpiration from a stand of remnant vegetation dominated by a coniferous *Callitris* species and a broad-leaved *Eucalyptus* species. (accepted: *Physiologia Plantarum*).

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## Abstract

This thesis presents the results of work undertaken to examine daily, seasonal and annual patterns of water use by a native remnant woodland in temperate Australia. The focus of the study was on the two dominant tree species of the woodland, but limited assessments of understorey and soil evapotranspiration were also undertaken. One of dominant species was *Eucalyptus crebra*, a broad-leaved tree and the other was *Callitris glaucophylla* a needle-leaved tree. At the start of the study, much of the eastern seaboard of Australia experienced a severe and prolonged drought but towards the end of the field work, rainfall at the site was significantly larger than the long-term average. This provided a fortuitous opportunity to compare the responses of vegetation water use to drought and non-drought periods.

The study was conducted on the Liverpool Plains, of western New South Wales, Australia. Principle methods applied were (a) use of heat-pulse technology to measure rates of sap flow through trees; (b) open-top chambers to measure understorey and soil evapotranspiration; (c) application of the Penman-Monteith equation to estimate canopy conductance and transpiration rates; (d) two methods to scale spatially from measurements of individual trees to estimates of stand water use; (e) three methods to scale temporally from measurements conducted over a few weeks each year to provide annual estimates of stand water use; (f) a simple water balance was constructed to approximate the rate of deep drainage of water (rate of recharge). An annual water budget for the site was estimated for the drought and post-drought periods.

The relationship between tree water use and diameter at breast height (DBH) was similar for the two species in each season, but the relationship for both species differed between seasons and years. In contrast, the relationships amongst DBH, sapwood area and leaf area differed between species at all times. This suggests that

the same rate of water use by the eucalypt and *Callitris* (at a common size) was achieved through different mechanisms.

Daily rates of stand water use showed significant intra- and inter-seasonal variation, with the lowest rates observed in winter and largest rates in summer. A simple model based upon solar radiation and vapour-pressure deficit was able to account for approximately 80 % of variation of stand water use under summer conditions with wet soil.

Estimates of stand water use derived from the Penman-Monteith equation generally agreed well with those based upon measurements of sap velocity, with a slope of the regression of the two estimates being 1.03.

In the drought-year, stand water use was approximately 59 % of rainfall and recharge was approximately 2% but in the post-drought year, when rainfall doubled compared to the drought year, stand water use was also 59 % whereas recharge was 4 %. This showed that despite the impact of an extensive and pronounced drought, the trees were able to rapidly adjust to more favourable conditions and maintain a low rate of recharge.

These results are discussed in relation to the management of water resources for human consumptive use and in relation to the development of dryland salinity across Australian landscapes that have been cleared of trees.

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## List of Abbreviations

° C	Degrees Celsius
ANCOVA	Analysis of Co-variance
ANOVA	Analysis of Variance
cm	Centimetre
DBH	Diameter at Breast Height (cm)
$E_{hp}$	Transpiration estimated using the heat pulse system ( $\text{mm}^3$ water $\text{day}^{-1}$ $\text{mm}^2$ leaf area)
$E_{PM}$	transpiration estimated using the Penman Monteith equation
$E_{SAxSV}$	Stand transpiration estimated by multiplying the stand sapwood area by sap velocity ( $\text{mm}^3$ water $\text{day}^{-1}$ $\text{mm}^{-2}$ ground area)
$E_u$	Understorey evapotranspiration ( $\text{mm}^3$ water $\text{day}^{-1}/\text{hr}^{-1}$ $\text{mm}^{-2}$ ground area)
$G_a$	Aerodynamic conductance
$g_s$	Leaf scale stomatal conductance
$G_s$	Canopy scale stomatal conductance
$G_c$	Stomatal canopy conductance at the canopy scale.
$G_{smax}$	Maximum stomatal conductance at the tree scale
ha	Hectare
h	Hour
$J_s$	Sap flux ( $\text{cm}^3 \text{ day}^{-1} \text{ cm}^{-2}$ )
kPa	Kilo Pascal
LA	Leaf Area ( $\text{m}^2$ )
LAI	Leaf Area Index ( $\text{m}^2 \text{ m}^{-2}$ , unitless)
m	Meter
mm	Millimetre
MPa	Mega-Pascal
NMM	Neutron Moisture Meter
Q	sap flow ( $\text{m}^3 \text{ day}^{-1}$ )
s.e.	standard error

VPD          Vapour Pressure Deficit (kPa)